Schlumberger is the most experienced high temperature service provider. With a suite of best-in-class technology and high-temperature-certified engineers, we provide high temperature (HT) drilling services.
An Industry Challenge

High temperatures can cause severe damage to downhole tool components, which include sensors for direction and inclination, gamma ray, annular pressure while drilling, complex LWD measurements, elastomer dynamic seals, lithium batteries, and electronic components and the boards on which they are mounted.

Currently, two types of high-temperature electronic components are available—plastic-encapsulated and ceramic-encapsulated, both of which are mounted on plastic boards. The reliability of a system composed of plastic boards will always be linked to the plastic component.

Industry and research studies show that plastic-encapsulated components have a life expectancy of approximately 1,000 hours at 150 degC [300 degF], which drops to 100 hours at 175 degC [350 degF]. Ceramic-encapsulated components, designed for the US military, last longer—at 175 degC [350 degF]—but they are bigger and heavier than their plastic counterparts. Since space is restricted in the tools, the best solution is a mix of both ceramic and plastic components.

It is also becoming more difficult to purchase HT electronic components because the US military has stopped requiring ceramic-encapsulated components, and the demand for them in the oil field is low. As a result, electronics providers have less incentive to manufacture them.

To find an electronic solution to this industry-wide problem, Schlumberger made a huge investment in the last 8 years in developing electronic components that would withstand high downhole temperatures. Employing the knowledge and experience of its experts in research, engineering, and field applications, Schlumberger developed its proprietary ceramic electrics technology, which is now incorporated in an MWD service and an RSS that is capable of operating in HT environments up to 200 degC [400 degF]. Field testing is in progress to ensure the technology meets the high reliability expectations of our customers.
Life Expectancy of Electronic Components

Plastic-encapsulated electronics on a plastic board (left), and ceramic-encapsulated electronics on a plastic board (right).
Preparation and Planning—The Keys to Successful HT Operations

All Schlumberger HT field engineers and HT maintenance technicians are certified through a comprehensive training and examination process. Our HT operations are planned and executed according to stringent procedures, and to ensure optimal performance, our tools undergo rigorous maintenance before and after each HT job—using our HT Drilling Maintenance Procedures.

The HT Drilling Maintenance Procedures bring together the best practices from Schlumberger maintenance facilities throughout the world, which have been involved in preparing tools for HT operations for many years. We also have an HT Global Help Desk dedicated to assisting operations, regularly updating our HT procedures, and answering HT queries from all over the world.

Prepare for and plan HT operations properly. It’s the key to successful operations. Our HT maintenance technicians are certified through comprehensive training and examination processes. Our HT operations are planned and executed according to stringent procedures. To ensure optimal performance, our tools undergo rigorous maintenance before and after each HT job—using our HT Drilling Maintenance Procedures. Schlumberger is the most experienced HT provider, with a wealth of experience in maximizing tool reliability at high temperatures. The lessons we learned in pioneering wireline ceramic-encapsulated electronic technology and developing HT artificial lift pumping technology have been used to develop reliable sensors and elastomers for HT drilling operations. Many of our MLWD services are powered by downhole turbodrills rather than by lithium batteries—a huge advantage in high temperature environments—because batteries often rupture with prolonged exposure to high temperatures.

Our tools are designed to optimize heat dissipation, while generating as little heat as possible themselves. In addition, we have the operational know-how to operate our tools in the coolest possible pumping conditions, using M-I SWACO HT drilling fluid services. Our BHAs also benefit from complementary Smith Services offerings—Hydra-Jar AP hydraulic jars and Neyrfor Turbodrills.
Schlumberger is familiar with the unique service requirements for each region where HT wells are drilled.

**North America**
The US has the world’s most intensive and extensive HT drilling. In the Haynesville shale play alone, hundreds of HT wells are drilled each year. These operations have tight budgets and require reliable HT service. Our HT expertise and our family of HT services—including PowerPak HT steerable motors, PowerDrive X6 HT rotary steerable systems, and the SlimPulse HT retrievable MWD service—offer a best-in-class solution for such operations.

**North Sea**
In the North Sea, where rig costs are high and wells are complex, HT drilling demands advanced technology. In that environment, technology such as PowerDrive X6 HT rotary steerable systems and the EcoScope HT multifunction LWD service make us the provider of choice. Even in the most adverse HT conditions, the EcoScope HT service delivers the most advanced LWD answers available to the oil and gas industry.

**Asia**
The second most active region for HT drilling—after the US—is China, Malaysia, Indonesia, and the Gulf of Thailand. Although HT challenges vary greatly from country to country, our unique geographical presence in this area and our wide range of HT services enable us to meet those challenges. In China, for example, the StethoScope HT formation pressure-while-drilling service performed nine pretests during 5 hours of operation in a complex reservoir with a temperature of 170 degC (340 degF).
Proven, High Temperature Operating Envelopes

Reliable Schlumberger HT downhole tools reduce the risks inherent in drilling and evaluating HT wells. We have a full range of DD/MLWD services.

<table>
<thead>
<tr>
<th>Service</th>
<th>Tool</th>
<th>Max. Operating Temperature</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>825 Collar</td>
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<tr>
<td>Turbodrill</td>
<td>Neyrfor Turbodrill</td>
<td></td>
</tr>
<tr>
<td>Motor</td>
<td>PowerPak HT</td>
<td></td>
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<tr>
<td>RSS</td>
<td>PowerDrive X6 HT</td>
<td></td>
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<tr>
<td>MWD</td>
<td>TeleScope HT</td>
<td></td>
</tr>
<tr>
<td>MWD-GR</td>
<td>SlimPulse HT</td>
<td></td>
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<td>MWD-GR-Res</td>
<td>ImPulse HT</td>
<td></td>
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<td>APWD</td>
<td>VPWD HT</td>
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<td>Sonic</td>
<td>SonicScope HT</td>
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<td>Full LWD</td>
<td>EcoScope HT</td>
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<td>FPWD</td>
<td>StethoScope HT</td>
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- Rated to 260 degC [500 degF]
- Rated to 190 degC [350 degF]
- Rated to 175 degC [350 degF]
- Rated to 165 degC [330 degF]

**PowerPak HT**

PowerPak HT steerable motors deliver dependable performance for drilling vertical, tangential, or horizontal hole sections, as well as oriented drilling for kickoffs or course corrections.

**MAIN SERVICES**
Steerable positive displacement motor service

**APPLICATIONS**
Performance and directional drilling

**ADVANCED FEATURES**
- Extra power (XP) or greater torque (GT) power sections
- High-speed, low-torque or low-speed, high-torque power sections
- Custom-fitted power sections for every application
- Mud-lubricated or oil-sealed bearing assemblies with optional sleeve stabilizers
- High-temperature elastomer for oil and water-based drilling systems

**OPERATING SPECIFICATIONS**
- Size: 2 1/8 in–1 1/4 in
- Mud: WBM/OBM/SOBM
- Max. operating temperature: 175 degC [350 degF]
- Horsepower: 15–709 hp tailoring drilling at the wellsite

**PowerPak ERT HT**

The PowerPak ERT HT high-performance motor delivers more than twice the torque output of conventional motors using even-rubber power section technology.

**MAIN SERVICES**
High-performance, steerable positive displacement motor service

**APPLICATIONS**
Performance and directional drilling

**ADVANCED FEATURES**
- High-torque transmission
- Angular contact bearings for increased WOB capability
- Surface adjustable bent housing for configuration at the wellsite

**OPERATING SPECIFICATIONS**
- Size: 4 3/4 in–9 5/8 in
- Mud: WBM/OBM/SOBM
- Max. operating temperature: 150 degC [300 degF]
- Torque: 280–24,000 ft.lbf
- Horsepower: 15–709 hp tailoring drilling at the wellsite
PowerDrive X6 HT
PowerDrive X6 HT rotary steerable systems improve performance and reliability with a wider operating envelope.

**PROVEN HT OPERATING ENVELOPE**

**MAIN SERVICES**
Fully rotating rotary steerable directional service

**APPLICATIONS**
Performance drilling

**ADVANCED FEATURES**
Real-time data using TeleScope HT services
Continuous near-bit surveys (inclination and azimuth)
Near-bit shock and vibration data
Near-bit azimuthal gamma ray for geosteering
Automatic inclination hold
Bit rpm

**OPERATING SPECIFICATIONS**
Hole size: 825: 10 5/8 in – 11 5/8 in
675: 8 1/2 in – 9 7/8 in
475: 5 1/2 in – 6 7/8 in
Mud: WBM/OBM/SOBM
Max. operating temperature: 175 degC (350 degF)
Max. build: 825: 6° /100 ft
675/475: 8° /100 ft
Flow range:
825: 300–2,000 gaUS/min
675: 200–950 gaUS/min
475: 100–380 gaUS/min
Low/med/high flow configurations
Max. pressure: 20,000 psi
Max. rpm: 220 rpm

PowerDrive vorteX HT
PowerDrive vorteX HT powered RSS have additional torque capacity that allows a higher weight on bit (WOB) for increased ROP.

**PROVEN HT OPERATING ENVELOPE**

**MAIN SERVICES**
Powered rotary steerable directional service running a PowerDrive X6 HT bias unit

**APPLICATIONS**
High-performance directional drilling with increased downhole power

**ADVANCED FEATURES**
Multiple stabilization options
Automatic inclination hold
Integrated high-performance power section

**OPERATING SPECIFICATIONS**
Operating and mechanical specifications dependent on collar size (8 1/4 in – 4 7/8 in)
Max. operating temperature: 175 degC (350 degF)
Max. pressure: 20,000 psi

PowerV HT
PowerV HT vertical drilling systems drill from spud to TD while automatically keeping the well vertical.

**PROVEN HT OPERATING ENVELOPE**

**MAIN SERVICES**
Fully rotating rotary steerable directional service

**APPLICATIONS**
Automatic vertical drilling optimization

**ADVANCED FEATURES**
Combinable with PowerDrive vorteX HT RSS

**OPERATING SPECIFICATIONS**
Same operating specifications as PowerDrive X6 HT system for the selected collar size (8 1/4 in – 4 7/8 in)
Max. operating temperature: 175 degC (350 degF)
Max. pressure: 20,000 psi

TeleScope HT
The TeleScope HT high-speed telemetry-while-drilling service provides real-time information for optimizing well placement, improving drilling efficiency, and reducing risk.

**PROVEN HT OPERATING ENVELOPE**

**MAIN SERVICES**
Real-time data
[0.5–12 bps physical rate, >100 bps effective rate]
Toolface
Direction and inclination
Downhole tool power
Continuous rotary surveys

**APPLICATIONS**
Real-time measurement and data transmission
Fast drilling sections where high-density data is needed

**ADVANCED FEATURES**
Telemetry capabilities to maximize real-time data delivery/efficiency
Power to more HT LWD tools than previously possible

**OPERATING SPECIFICATIONS**
Max. operating temperature: 175 degC (350 degF)
Max. pressure: 25,000 psi
HP option: 30,000 psi
**ImPulse Gamma Ray-Resistivity**

The ImPulse HT integrated MWD platform provides survey, gamma ray, and resistivity measurements while drilling. The measured data is transmitted in the quickest possible mode with a state-of-the-art telemetry system.

**PROVEN HT OPERATING ENVELOPE**

![Graph showing operating envelope for ImPulse HT](image)

**MAIN SERVICES**
- Real-time density and porosity with adnVISION HT tool
- Invasion profiles
- Phase caliper in WBM

**OPERATING SPECIFICATIONS**
- Mud: OBM/WBM/SOBM
- Max. operating temperature: 175 degC (350 degF)
- Max. tool curvature: 15/100 ft rotating, 30/100 ft sliding
- Max. flow rate: 400 galUS/min
- Max. pressure: 25,000 psi

**APPLICATIONS**
- Real-time survey, gamma ray, and resistivity measurements

**ADVANCED FEATURES**
- Reliable, precise real-time measurements for all general drilling

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**VPWD HT**

VPWD HT collar-mounted telemetry and surveying systems measure internal and annular pressure while drilling. The service supplies battery power to obtain logging data while tripping.

**MAIN SERVICES**
- APWD annular pressure while drilling
- Annular temperature while drilling
- Internal pressure while drilling

**APPLICATIONS**
- Real-time data using ImPulse HT service

**ADVANCED FEATURES**
- Formation integrity and leakoff tests

**OPERATING SPECIFICATIONS**
- Max. operating temperature: 165 degC (330 degF)
- Max. tool curvature: 15/100 ft rotating, 30/100 ft sliding
- Max. flow rate: 400 galUS/min
- Max. pressure: 25,000 psi

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**arcVISION HT**

The arcVISION HT array resistivity compensated service provides resistivity, gamma ray, and annular pressure while drilling measurements.

**PROVEN HT OPERATING ENVELOPE FOR GR, RESISTIVITY, AND APWD**

![Graph showing operating envelope for arcVISION HT](image)

**MAIN SERVICES**
- 20 multidepth, dual-frequency resistivities
- Phase and attenuation measurements—16-, 22-, 28-, 34-, and 40-spacings

**APPLICATIONS**
- Well-to-well correlations
- Well placement
- Drilling-induced fracture identification (time lapse)

**ADVANCED FEATURES**
- Phase caliper in WBM

**OPERATING SPECIFICATIONS**
- Mud: OBM/WBM/SOBM
- Max. operating temperature: 175 degC (350 degF)
- Max. tool curvature: 825: 7/100 ft rotating, 14/100 ft sliding, 675: 8/100 ft rotating, 16/100 ft sliding
- Max. flow rate: 825: 1,950 galUS/min, 675: 800 galUS/min
- Max. pressure: 25,000 psi; HP option: 30,000 psi

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**SlimPulse HT**

The SlimPulse HT retrievable MWD service makes direction and inclination, toolface, and gamma ray measurements in real time for mud pulse telemetry. It runs the Orion II telemetry platform, which improves data transmission rate.

**PROVEN HT OPERATING ENVELOPE**

![Graph showing operating envelope for SlimPulse HT](image)

**MAIN SERVICES**
- Real-time and memory data
- Gamma ray
- Toolface
- Direction and inclination
- Continuous rotary surveys
- Shock and vibration
- Stick/slip

**APPLICATIONS**
- Reliable, precise real-time directional measurements
- Wireline retrievable and reseatable for efficiency and risk mitigation
- Short radius drilling
- Re-entry wells

**ADVANCED FEATURES**
- Downlink capability to allow transmission speed selection or change data being transmitted

**OPERATING SPECIFICATIONS**
- Body OD: 1 3/4 in
- Pulse OD: 1 1/8 in, 2 1/8 in, 2 3/8 in, 2 5/8 in
- Mud: OBM/WBM/SOBM
- Max. operating temperature: 175 degC (350 degF)
- Max. tool curvature: 50°/100 ft
- Max. pressure: 20,000 psi; HP option: 22,500 psi

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**Note:** Includes arcVISION, VPWD, and EcoScope runs.
adnVISION HT

The adnVISION HT azimuthal density neutron service provides real-time apparent neutron porosity, formation bulk density, and photoelectric factor (PEF) data.

PROVEN HT OPERATING ENVELOPE FOR DENSITY AND NEUTRON

- 400 degC
- 350 degC
- 300 degC
- 200 degC
- 150 degC

0 100 200 300 400

Pumping hours

Note: Includes adnVISION and EcoScope runs.

MAIN SERVICES
- Azimuthal density/PEF
- Neutron porosity
- Ultrasonic caliper
- Downhole shocks/rpm
- Real-time data using TeleScope HT service

APPLICATIONS
- Formation evaluation
- Formation dip
- Fault identification
- Thin-bed identification
- Caliper applications

ADVANCED FEATURES
- Borehole invariant porosity
- Slick or stabilized
- Wireline retrievable sources/data

OPERATING SPECIFICATIONS
- Hole size: 675: 8 1/4 in–8 1/2 in
- 475: 5 3/4 in–6 3/4 in
- Max. operating temperature: 175 degC (350 degF)
- Max. tool curvature:
  - 675: 4.5°/100 ft rotating (IBS collar)
  - 10°/100 ft rotating (slick)
  - 15°/100 ft rotating (slick)
  - 30°/100 ft sliding
- Max. flow rate:
  - 675: 800 galUS/min
  - 475: 400 galUS/min
- Max. pressure: 25,000 psi

sonicVISION HT

The sonicVISION HT sonic-while-drilling service provides reliable, real-time velocity measurements that enable safe, efficient HT drilling in hole sizes up to 30 in.

MAIN SERVICES
- Borehole compensated sonic
- Real-time monopole compressional and shear data
- Real-time slowness-time-coherence (STC) projections
- Real-time data TeleScope HT service

APPLICATIONS
- Real-time pore pressure management
- Real-time rock mechanics with real-time STC projections
- Formation damage indicator
- Top-of-cement identification
- Synthetic seismogram for seismic tie-in
- Sonic porosity
- Hydrocarbon identification

ADVANCED FEATURES
- Variable density log
- Pumps off delta-T compressional

OPERATING SPECIFICATIONS
- Mud: OBM/WBM/SOBM
- Max. operating temperature: 175 degC (350 degF)
- Max. tool curvature:
  - 825: 6°/100 ft rotating
  - 14°/100 ft sliding
  - 16°/100 ft sliding
- Max. flow rate:
  - 825: 1,200 galUS/min
  - 675: 800 galUS/min
- Max. pressure: 25,000 psi
- HP option: 30,000 psi

SonicScope 475 HT

SonicScope 475 HT multipole sonic-while-drilling service delivers reliable, high-quality compressional and shear data for reduced drilling risk and cost, more effective mud program management, accurate seismic positioning, and completion design optimization to enhance production.

MAIN SERVICES
- Borehole compensated sonic
- Real-time monopole compressional and shear data
- Recorded multipole
- Real-time slowness-time-coherence projection
- Real-time data using ImPulse HT service

APPLICATIONS
- Real-time pore pressure monitoring of borehole stability
- Top-of-cement identification
- Sonic-to-seismic processing
- Fracture detection
- Porosity evaluation and hydrocarbon identification
- Perforation location optimization
- Hydraulic fracture optimization

ADVANCED FEATURES
- Robust shear data in slow formations
- Real-time compressional and shear data

OPERATING SPECIFICATIONS
- Hole size: 5 5/8 in–8 in
- Mud type: OBM/WBM/SOBM
- Max. operating temperature: 175 degC (350 degF)
- Max. tool curvature:
  - 15°/100 ft rotating
  - 30°/100 ft sliding
- Max. flow rate: 400 galUS/min
- Max. pressure: 25,000 psi

StethoScope HT

The StethoScope HT formation pressure-while-drilling service provides real-time calibration points for pore pressure models. Its reliable pressure measurements can be used to optimize mud weight and improve casing point selection.

MAIN SERVICES
- Real-time formation pressure
- Annular pressure during pretests
- Real-time data using TeleScope HT service

APPLICATIONS
- Mud weight optimization
- Pore pressure calibration
- Pressure geosteering
- Gradient analysis
- Fluid contacts

ADVANCED FEATURES
- Real-time mobility
- TOP time-optimized pretest
- “On demand” frame interpreted pretests

OPERATING SPECIFICATIONS
- Diameter reach: 8 1/2 to 10 1/2 in
  - (11 1/2 in max. with 9 1/4-in stabilizer)
- Max. operating temperature: 165 degC (330 degF)
- Max. tool curvature:
  - 8°/100 ft rotating
  - 16°/100 ft sliding
- Max. flow rate: 800 galUS/min
- Max. pressure: 25,000 psi
EcoScope HT

The EcoScope 675 HT multifunction LWD service integrates a full suite of formation evaluation, well placement, and drilling optimization measurements into a single collar. Using the Orion II telemetry system, it is capable of delivering real-time data at up to 120 bps without loss of data resolution, even at high penetration rates.

PROVEN HT OPERATING ENVELOPE FOR GR, RESISTIVITY, APWD, DENSITY AND NEUTRON

MAIN SERVICES
- Neutron porosity
- Bulk density
- Dual-frequency, array induction resistivity
- Elemental capture spectroscopy
- Formation sigma
- Azimuthal and image measurements
  - Natural gamma ray
  - Gamma-gamma density
  - Photoelectric factor (PEF)
- Ultrasonic caliper
- Dual-sensor ultrasonic caliper
- Inclination
- Multi-axis shocks
  (3-axis & torsional)
- Collar rpm
- APWD annular pressure
  while drilling
- Full real-time capability

APPLICATIONS
- Well-to-well correlation
- Formation evaluation
- Formation dip
- Fault and thin-bed identification
- Caliper applications
- Well placement
- Drilling-induced fracture identification

ADVANCED FEATURES
- Sourceless operations with neutron-gamma density
- Drilling dynamics data

OPERATING SPECIFICATIONS
- Hole size: 8 1/2 in–9 5/8 in
- Max. operating temperature: 200 degC (392 degF)
- Max. tool curvature: 8'/100 ft rotating
  18'/100 ft sliding
- Max. flow rate: 800 gal/min
- Max. pressure: 20,000 psi

Neyrfor Turbodrill

Neyrfor HT high-performance turbodrills are designed with a fully concentric drive-train rotation to maintain optimal power while remaining on bottom for extended periods of time. For directional and horizontal turbodrill applications, Neyrfor Turbodrills provide consistent, predictable drilling rates.

PROVEN HT OPERATING ENVELOPE

APPLICATIONS
- Performance and directional drilling
- Directional or horizontal applications
- Customized one up to three power sections

ADVANCED FEATURES
- Drilling-induced fracture identification
- Directional or horizontal applications
- Surface adjustable bend housing for directional or horizontal applications

OPERATING SPECIFICATIONS
- Hole size: 3 1/4–17 1/2 in
- Mud: WBM/DBM/DBBM
- Max. operating temperature: 260 degC (500 degF)
- Torque: 215–9,020 ft.lbf
- Horsepower: 74–710 hp

ENVIROTHERM NT

The ENVIROTHERM NT drilling system is an HPHT chrome-free, water-base fluid that maintains its stable properties while drilling, and during the prolonged static conditions experienced during tripping, logging, and testing operations.

MAIN SERVICES
- Water-base drilling fluid

APPLICATIONS
- High temperature wells in shale plays
- Environmentally sensitive operations
- Projects requiring water-base drilling fluid systems

ADVANCED FEATURES
- HPHT rheology stabilizer
- Fluid-loss control
- Secondary viscosifier
- Chrome-free HPHT thinners
- Shale/filtercake sealing additive

OPERATING SPECIFICATIONS
- Type: Water-base fluid
- Max. operating temperature: 177 degC (350 degF)

Hydra-Jar AP

Smith Services double-acting HT hydraulic impact tools for high temperature are capable of delivering a heavy impact when a BHA becomes stuck. A temperature compensation feature enables them to run at higher operating temperatures and in harsher environments.

APPLICATIONS
- Impact to free stuck drillstem components
- Land or offshore operations, vertical or deviated wells, and ultradeep or ultrahot boreholes

ADVANCED FEATURES
- Reduced risk of lost equipment
- Prevention of costs to plug back and sidetrack
- High-temperature seals

OPERATING SPECIFICATIONS
- Hole size: 4 1/2 in–26 in
- Max. operating temperature: 260 degC (500 degF)
- Jarring force: > 1,000,000 lbf